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Art. VIII.—*Isograptus caduceus and its Allies in Victoria.*

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(With Plate VI.).

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Part I.

I. Introduction.

The evolution of the graptoloidea has been worked out in considerable detail in Britain and North America by G. L. Elles(6) and R. Ruedemann(20, 21) respectively, tabular diagrams being given which indicate hypothetical lines of descent. Much detailed work has still to be done in Australia and New Zealand before similar comprehensive schemes can be attempted here. The present paper is intended as an essay of much more restricted scope, devoted to one small part of the subject. It may be suggested, however, that study of etched specimens on the lines laid down by Holm and followed so successfully since,

especially by Bulman(3), will revolutionize our ideas of structure and therefore of phylogeny. There will always be the handicap that this scientific method is applicable only to material preserved in a peculiar, and in most parts of the world, very exceptional way.

When a comparison is made between the graptolites of the northern hemisphere and those of Australia and New Zealand, certain resemblances and contrasts stand out clearly—for example, the rarity in one hemisphere of forms common in the other, and the development in one region of a particular group and its insignificance elsewhere. Many such cases could be given, e.g., the rise and decline in Victoria of *Tetragraptus fruticosus*, apparently not a common species in Great Britain(7), but in Victoria and New Zealand characteristic of a whole series of beds; the deployment of tuning-fork or dependent *Didymograpti* in Britain and in America, both North and South, and their monotony in Victoria, where only two clearly distinct species are at all common, and then only with a restricted and (compared with other countries) apparently anomalous range. The list could be added to, but perhaps no difference is more striking than the absence from northern records of any account of the series known here as the Darriwilian, and forming under the present classification the upper part of the Victorian Lower Ordovician. In keeping with this, and leading to it, is the development of *Isograptus caduceus* and its allies, the most easily followed of graptolite phylogenetic series and the one most reminiscent of better-known palaeontological phylogenies.

II. Synonymy.

The synonymy of *Didymograptus caduceus* has been a vexed question since Nicholson described as *Didymograptus gibberulus* forms which seem, beyond doubt, to have been included in Salter's original species, in fact the only *Didymograptus* Salter had in view when founding his species(22).

The species has been described as *Didymograptus caduceus* by McCoy(17) and T. S. Hall (9, 10) in Victoria, *D. gibberulus* (*Isograptus gibberulus*) by Elles and Wood(7), *D.* (*I.*) *caduceus* by Ruedemann(20), and lastly (as far as my records go) as *I. gibberulus* (Nicholson) by Bulman(3), who, however, if I read his note rightly, half apologizes for using Nicholson's specific name.

Those who wish to pursue the question of synonymy further are referred to the papers cited by the above authors, especially to the page of citations given by Bulman(3), but since the adoption of any other name but *caduceus* seems merely to be on the grounds of expediency I have decided after long consideration, and with the support of the opinions of Messrs. F. Chapman and R. A. Keble, to retain Salter's term *caduceus*.

Figures are given of the two forms named *Didymograptus caduceus,* Figs. 62, 63, by Salter(22), in 1853. They will give some idea of what Salter had in mind, but owing to the different method of reproduction they should not be considered without comparison with Salter's original figures. In conclusion, it may be added that Nicholson's dictum that the supposed *Tetragraptus* is narrowest over the proximal region where the *Didymograptus* is widest does not necessarily apply.

III. Characters of Isograptus caduceus—Isograptidae.

Nicholson and Marr(18) concluded that the character of the thecae is the most important point to retain in separating families, and that the next most important point in indicating genetic relationship is the angle of divergence of the stipes, while the number of stipes on which the classification of the graptolites at that time largely depended—as it still does to some extent—is relatively unimportant.

Elles(5), after comparison of thecal characters, number of thecae in a given length, their inclination, apertural angle, and overlap, confirmed Nicholson and Marr's opinion, and concluded that these resemblances are of genetic origin, and therefore of systematic value. These criteria are now generally accepted, but the classification of the graptolites conforms only roughly to them, and it seems hardly open to doubt that many present-day genera include forms with distinct ancestry, while separate genera have been erected for closely related species. This is particularly the case where vital generic characters are hard to distinguish, as in the group discussed in the present paper. Moreover, the basis for classification is only generally applicable; if not used with discretion and the realization that one is dealing with living, and, therefore mutable organisms, it breaks down completely. Elles herself, for example(6), devotes many pages to indicating the progression of thecal types in the same genus; the number of thecae per centimetre in *Isograptus caduceus* varies from 7 to 12, according to the variety, the apertural angle changes, as does also the amount of overlap. If, however, the characters discussed are regarded as subject to evolutionary change in recognizable directions, they afford great help in classification.

The interpretation of the development of the rhabdosome of *Isograptus caduceus* is one of great difficulty in the absence of uncompressed material. However, there seems no need to deal with the matter exhaustively here, as workers on the other side of the world have access to material showing details hidden from us. Reference is therefore made to Bulman's conclusive paper(3), and to complete the present description of the form

the following account of the initial stages of *Isograptus* is abridged from that paper: "The sicula is very long and narrow, averaging about 5 mm. in length. . . . The first theca (th 1^1) arises remarkably high up on the sicula, with which its dimensions are almost identical. . . . The crossing canal leading to th 1^2 passes very obliquely across the sicula and the theca to which it gives rise grows in contact with the sicula throughout its length. At an early stage it in turn gives off another crossing canal leading to th 2^1 which passes over th 1^1 at a more obtuse angle and then grows downward in contact with that theca. Subsequent development is of the normal didymograptid type, the second stipe developing from th 1^2 and the first stipe from th 2^1." (See Fig. 1.)

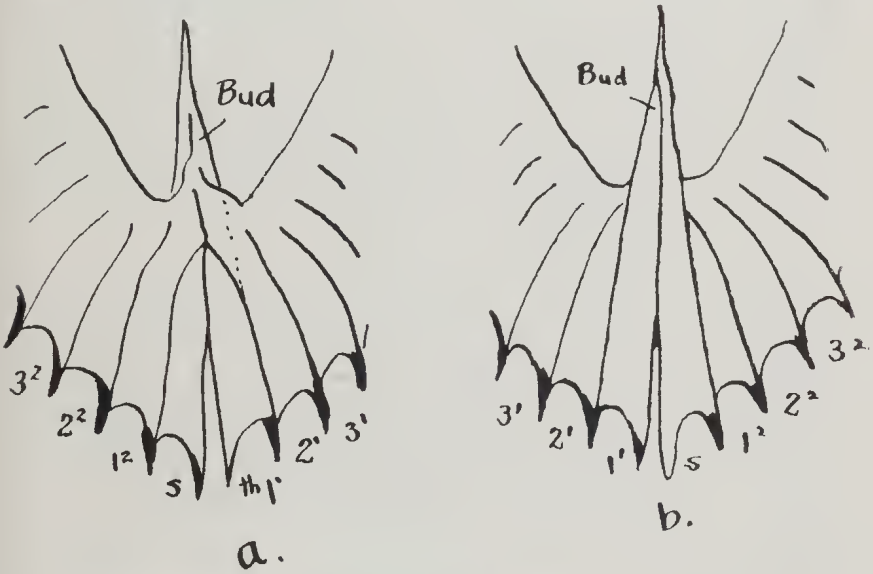


Fig. 1. Isograptus gibberulus (Nicholson).
Generalized figures (x10 approx.) showing the structure of the proximal end in reverse (*a*) and obverse (*b*) aspect.
(From Bulman Fig. 1 p. 24 Arkiv f Zool. Bd. 24A, 9.)

This account, and Bulman's figures, seem decisive on the question whether the initial V of the rhabdosome consists of th 1^1 and 1^2 or of the sicula and th 1^1, the latter being Bulman's interpretation, as first suggested by Tornquist(23) and Elles (4). Ruedemann's text figure (20, p. 695, fig. 89) would seem therefore to give a wrong impression, the sicula shown in the figure being probably a misinterpretation caused by thickening due to the crossing canal. I have noted similar appearances in my own specimens, and while some seem to show the long sicula as figured by Bulman, other certainly give the appearance shown in Ruedemann's figure.

While Bulman therefore, working on material prepared by Holm, has been able to show clearly the initial stages of *Isograptus caduceus,* confirming almost beyond doubt its deviation from the normal didymograptid type of development, his work, so successful in its immediate object, introduces the difficulty that certain reference of any form to the genus founded on these characters—*Isograptus*—will be possible only with exquisitely preserved material. Twenty years of close study of thousands of compressed but otherwise well-preserved specimens have not enabled me to verify Elles's and Bulman's conclusions from my own observations. Even now, with Bulman's figures as a guide, it is impossible to find any specimen which when figured will show clearly the initial stages of thecal budding. In fact, I know of only one Victorian locality where further search for uncompressed material seems promising—the slate quarry on the north bank of the Gisborne Creek in Allot. 43A, Bullengarook. Among the fallen blocks at this quarry—now in a dangerous state of disrepair—specimens were found in relief, showing even growth lines on the more distal thecae. In every case, however, the proximal parts were either lacking in relief or so crushed that the details could not be made out. Fortune may yet favour a worker at this locality.

If there is difficulty in recognizing the generic characters of *Isograptus* in the case of *I. caduceus,* the same difficulty is met in endeavouring to interpret the early stages of *Oncograptus* and *Cardiograptus.* Yet they seem beyond reasonable doubt to be related to each other and to *I. caduceus.* Here again the fortuitous discovery of well-preserved material must be awaited. The problem they present will be touched on later, but on general grounds it seems necessary to place them near *I. caduceus.* In certain forms which in the past have been brought under *I. caduceus* as varieties, e.g., var. *manubriatus* T. S. Hall(12), the differences in early stages and thecal type seem to make specific separation desirable.

Bulman (3, p. 26 *et seq.*) has pointed out the relationship between *Macandrograptus* Moberg and *Isograptus.* Associated with *Isograptus caduceus* in Victoria are forms which seem to connect *Macandrograptus* even more closely with *Isograptus* than the European material, which has nearer affinities with *Dicellograptus,* and the suggestion is made that *Macandrograptus* itself might best be considered as belonging to the same family as *Isograptus.* This conclusion is drawn from specimens deficient in detail, and cannot be put forward dogmatically. *Diplograptus gnomonicus* Harris and Keble, and *Didymograptus ovatus* T. S. Hall, are probably also related forms.

Summing up, it may be said that the present classification obscures the relationship of many forms, and unduly emphasizes their distinctiveness. I have therefore tried to overcome this

difficulty by a procedure which, while not free from objection, yet seems to achieve the object aimed at. This consists in removing *Isograptus* and allied forms from the *Dichograptidae* and forming for them a new family—Isograptidae. The differences between *Isograptus* and a typical member of the Dichograpitdae seem to be at least as great as those which separate the Leptograptidae from either the Dichograptidae or the Dicranograptidae, and the differences are greater if forms such as *Oncograptus* and *Cardiograptus* are considered. Besides, it cannot be contended that the present classification of the Graptolitoidea is biologically sound—it is based partly on biological factors and partly on external appearances. The new family of Isograptidae will include no forms other than those which, on strong evidence, seem to be genetically related, and is therefore a step in the direction of a natural classification of the graptolites.

The proposed classification is, therefore, as follows:—

Family Isograptidae, fam. nov.
Genus Isograptus Moberg.
Genotype Isograptus caduceus (Salter).

Species Isograptus caduceus (Salter) and its varieties.
„ forcipiformis (Ruedemann).
„ hastatus, sp. nov.
„ manubriatus (T. S. Hall partim).
„ dumosus, sp. nov.
„ ovatus (T. S. Hall).

Genus Oncograptus T. S. Hall.
Genotype Oncograptus upsilon T. S. Hall.

Species Oncograptus upsilon T. S. Hall, and var. biangulatus Harris and Keble.

Genus Cardiograptus Harris and Keble.
Genotype Cardiograptus morsus Harris and Keble.

Species Cardiograptus morsus Harris and Keble.
„ crawfordi Harris.

Genus Skiagraptus, gen. nov.
Genotype Diplograptus gnomonicus Harris and Keble.

Species Skiagraptus gnomonicus (Harris and Keble).

Genus Maeandrograptus Moberg.
Genotype M. Schmalenseei Moberg.

Victorian Species Maeandrograptus aggestus, sp. nov.
„ tau, sp. nov.

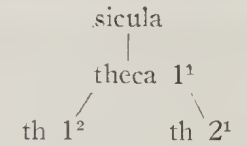
Unity is given to the whole series by progressive development along several lines:—

(i) The rhabdosome becomes increasingly scandent. Typical stages along this line of development are shown by *Isograptus caduceus*, varieties *victoriae* (Figs. 7-10), *maxima* (Figs. 11, 12), *maximo-divergens* (Fig. 13), and *divergens* (Figs. 14-18).

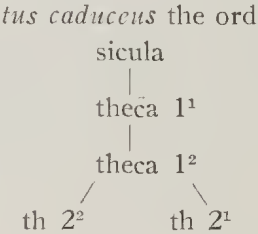
Perhaps parallel to this is the line of *Isograptus forcipiformis* (Figs. 27-29) and *Skiagraptus gnomonicus* (Fig. 30). The stages exemplified by these forms are shown on a larger scale by *Oncograptus* (Figs. 19-24) and *Cardiograptus* (Figs. 25, 26).

(ii) There is progression and then regression in the form of thecal aperture. The apertures are, even in early forms, soon directed outwards, almost parallel to the axis of the rhabdosome. At first, the denticles or mucros are almost at right angles to the apertural margins (Figs. 3, 4), but later they become recurved and directed sicula-wards (Figs. 12-17). Still later this curvature diminishes, and a stage reminiscent of earlier varieties is reached (Figs. 43, 44). In some of the later forms, such as *I. hastatus* (Fig. 36) and *I. dumosus* (Fig. 39) the apertures are directed more upwards than outwards, and the thecae show divergence from the typical trumpet-shaped tubes of the type. Divergence of thecal type is shown even more by *M. tau* (Figs. 47-49) and *Maeandrograptus aggestus* (Fig. 51). On the other hand, forms which cannot on present evidence be connected with *Isograptus,* such as *Phyllograptus nobilis* Harris and Keble(14) show the typical *I. caduceus* thecae.

(iii) More important is the effect of concrescence. This may be regarded as the chief basis of the family. Thus in *Dichograptus* the order of thecal origins is—



In *Isograptus caduceus* the order is—



This is the first step in the grouping of thecal origins in the region of the sicula which leads to condensation of the whole rhabdosome and is in direct opposition to what may be called the dichograptid stage, where rapid budding produces a diffuse rhabdosome.

Although later developments show normal theca-to-theca budding, there persists the tendency to group thecal origins so that initially biserial stipes arise. This, though dichograptid in character, is comparable with the result produced by diplograptid development.

IV. Ancestry of Isograptus caduceus.

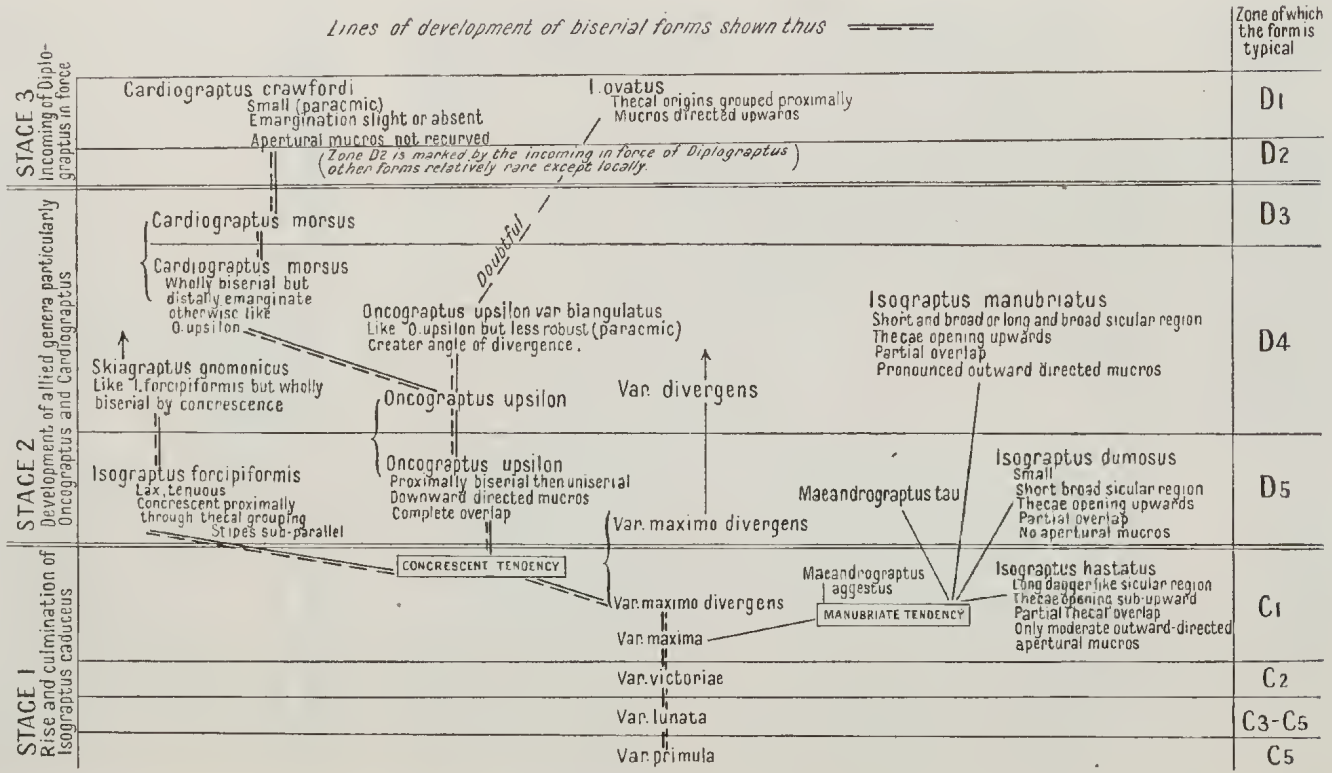
Elles does not include this form among the species in her phylogenetic table(6). Ruedemann(20, p. 554) derives it from *Staurograptus dichotomus* var. *apertus,* through *Bryograptus* and *Tetragraptus similis. Staurograptus* is itself derived from *Clonograptus*(21, p. 119). This scheme seems open to objection, for though *Staurograptus* is spoken of as " a closely related vicarious form of *Clonograptus tenellus*" (21, p. 130), the *Clonograptus* beds are placed above the *Staurograptus* horizon, a position they occupy in Australia. The derivation of *Isograptus* from *Tetragraptus similis* (*T. bigsbyi*) also seems doubtful. This latter derivation was strengthened by the confusion which prevailed between the two forms before the specific criteria were well recognized, but there are important differences between the two species in thecal characters and in the initial stages. Derivation from *Tetragraptus serra* (=*T. bryonoides*) might, perhaps, be as plausibly suggested, though as a matter of fact there is little resemblance between the earliest Victorian *I. caduceus* and any other form, and in the absence of connecting links, the chain of descent is not obvious. The earliest *I. caduceus* is a small form, and the typical horse-shoe rhabdosome has gradually developed. Forms with superficial resemblance occur at one locality at least on a much lower horizon—at Campbelltown, south-west of Castlemaine—with *Tetragraptus approximatus,* and possibly also at Romsey, but they have not been found in intervening zones, and their relationship to *I. caduceus* is very doubtful. They are described in a later section of this paper.

V. Table showing Hypothetical Development of Isograptus caduceus (Salter) and Allied Forms.

NOTES ON TABLE.

1. Stage 1 shows progressive increase in—
   (*a*) size of rhabdosome, accompanied by more open spacing of thecae;
   (*b*) angle of divergence;
   (*c*) downward directing of apertural mucros;
   (*d*) completeness of thecal overlap.

2. Stage 2 shows deployment into allied genera (begun in C1). *Oncograptus upsilon* and *Cardiograptus morsus* are the only forms which do not seem distinctly paracmic, and even these are very variable.


Lines of development of biserial forms shown thus
Zone of which the form is typical
STAGE 3
Incoming of Diplograptus in force
STAGE 2
Development of allied genera particularly Oncograptus and Cardiograptus
STAGE 1
Rise and culmination of Isograptus caduceus
Cardiograptus crawfordi
Small (paracmic)
Emargination slight or absent
Apertural mucros not recurved
(Zone D2 is marked by the incoming in force of Diplograptus other forms relatively rare except locally.
I. ovatus
Thecal origins grouped proximally
Mucros directed upwards
D1
D2
Cardiograptus morsus
D3
Cardiograptus morsus
Wholly biserial but distally emarginate otherwise like O. upsilon
Doubtful
Oncograptus upsilon var biangulatus
Like O. upsilon but less robust (paracmic)
Greater angle of divergence.
Isograptus manubriatus
Short and broad or long and broad sicular region
Thecae opening upwards
Partial overlap
Pronounced outward directed mucros
Skiagraptus gnomonicus
Like I. forcipiformis but wholly biserial by concrescence
Oncograptus upsilon
Var. divergens
D4
Isograptus forcipiformis
Lax, tenuous
Concrescent proximally through thecal grouping
Stipes sub-parallel
Oncograptus upsilon
Proximally biserial then uniserial
Downward directed mucros
Complete overlap
Maeandrograptus tau
Isograptus dumosus
Small
Short broad sicular region
Thecae opening upwards
Partial overlap
No apertural mucros
D5
CONCRESCENT TENDENCY
Var. maximo divergens
Maeandrograptus aggestus
MANUBRIATE TENDENCY
Isograptus hastatus
Long dagger like sicular region
Thecae opening sub-upward
Partial thecal overlap
Only moderate outward-directed apertural mucros
Var. maximo divergens
Var. maxima
C1
Var. victoriae
C2
Var. lunata
C3-C5
Var. primula
C5

The stage is marked by—

(*a*) tendency towards reduction in size (maximum reached in *O. upsilon*) with closer thecae;

(*b*) still increasing angle of divergence leading to biserial forms;

(*c*) variation in mucros—pronounced in some forms, absent in other species;

(*d*) reduction of thecal overlap in manubriate forms;

(*e*) grouping of thecal origins in sicular region as distinct from concrescence, but shown with concrescence in forms like *Oncograptus* and *Cardiograptus*.

3. Stage 3 marks the extinction of the group except for rare examples. Some of the earlier forms persist into Zone D1, e.g., *I. forcipiformis, Skiagraptus gnomonicus,* and even *I. caduceus* var. *divergens*.

4. The evidence is insufficient to place definitely *M. aggestus* and *M. tau*. *M. aggestus* is probably closest to *I. dumosus*, and *M. tau* to *I. hastatus*.

5. The catagenetic varieties of *I. caduceus*, except *I. caduceus* var. *divergens*, are not shown on the table. They are commonest in C1 and D5, and show great variability, making grouping difficult. Practically all agree in having distally-narrowing stipes.

VI. Isograptus caduceus and its Varieties.

McCoy(17), as mentioned, included all his variations in the same species, without even varietal names. He remarks, "I at first conceived the large wide divergent forms distinguishable as at least a marked variety from the narrow sub-parallel forms first noted by Salter from the Lauzan Precipice, Point Levis, Quebec, but the very great number of specimens I have now examined convinces me that no concurrence of characters can be got to separate specifically the extremes of form here figured and described, and that from small specimens, perfectly identical with the original type in everything, to the largest forms here made known, there is the most gradual and irregular transition of characters." McCoy then did not connect development with stratigraphical position, and his opinion of "irregular transition" may be regarded as hardly accurate.

T. S. Hall(9) took the first step, pointing out the gradual increase in size and numbers of the species throughout the Castlemaine series. Later field work has shown that the maximum development is reached in the highest Castlemainian (C1) and lowest Darriwilian (D5) beds, after which there is a comparatively rapid decline both in numbers and character. In fact, associated with the acmic forms in the C1 zone are many which already show variation. In the middle and upper Darriwilian the specimens diverge further from the Castlemainian type, and the species disappears after rare occurrence in the lowest beds of the Upper Ordovician. Variation, as distinct from development, begins as low as C2, if not lower, but

becomes important only in the next higher zone or in beds transitional between C2 and C1. Above the lower Darriwilian the typical horseshoe-shaped rhabdosome is rare.

It is proposed to deal with the various developmental forms of *Isograptus caduceus* under stratigraphical headings, and, as already stated, to show by this method that a progressive development can be traced till the acmic stage is reached, though forms with the characters of lower-zone varieties persist alongside others more advanced. This is particularly noticeable in the Upper Castlemainian (C1) (Figs. 55-59).

VII. Stratigraphical.

(*a*) *Lower to Middle Castlemainian* (*C5—C3*).

In the lowest Castlemaine zone (C5—Zone of *Didymograptus bifidus*) two varieties may be distinguished, both small. The first (Figs. 1, 2) is broad over the sicular region, has few thecae —usually two or three in each stipe—and the stipes usually narrow rapidly. This form is now distinguished as var. *primula*. The later form which it most closely resembles is the juvenile stage of the Victoria Gully (C2) variety (Fig. 60). The second variety is a typically horseshoe-shaped rhabdosome with narrow stipes showing little variation in width (Figs. 3-6). This variety —*lunata*—ranges as high as C3 and is echoed by a paracmic form in C1 (Fig. 57), but var. *primula*, as far as my observations go, is confined to the Wattle Gully beds (C5). Even in var. *lunata* the tendency towards increase in the angle of divergence of the stipes, afterwards so prominent, is sometimes noticeable (Fig. 4).

(*b*) *Victoria Gully Beds* (*C2*).

The typical Victoria Gully form, var. *victoriae* (Figs. 7-10) is easily recognized by its more robust character, its typical horseshoe form, and often by a long nema. The V between the sicula and th 1^1 is usually distinct—it is shown even in C5 forms—and the stipes narrow only slightly distally. This is the form which might best be regarded as *Isograptus caduceus, forma typica* (Fig. 9), but in the progressive series it may be distinguished as a variety, though until the C1 horizon is reached the so-called varieties are really stages along a line of progressive development.

(*c*) *Upper Castlemainian and Lower Darriwilian* (*C1—D4*).

Transitional beds between the Victoria Gully horizon (C2) and that of McKenzie's Hill (highest Castlemainian) are to be found, in which the commonest form is a robust var. *victoriae*. In the C2 and C1 beds *Isograptus caduceus* comprises the

majority of all graptolites present—80 per cent. in C2 according to Hall's estimate(9), and an even greater proportion in C1. The robust var. *victoriae* passes insensibly into var. *maxima* (Figs. 11, 12). This variety still preserves the typical horse-shoe-shaped rhabdosome, but by narrowing of the stipes at the point of flexure, and increase of the angle of divergence, it passes insensibly into var. *maximo-divergens* (Fig. 13). These two varieties represent the acmic stage of *I. caduceus*. Specimens of var. *maximo-divergens* may be obtained with stipes 5 cm. long and 5 mm. wide (Fig. 14). By still greater narrowing of the stipes at the angle of flexure and a gradual loss of robustness, var. *maximo-divergens* passes into var. *divergens* (Figs. 14-18), which is commonest in the middle Darriwilian (D4—D3). The large forms which bridge the gap between var. *maxima* and var. *divergens* are stratigraphically and biologically important, for it was at this stage that *Oncograptus* developed.

(*d*) *Middle and Upper Darriwilian* (D4—D1).

In these beds *Isograptus caduceus* becomes rarer as the higher zones are reached, though there are isolated high outcrops where it is locally abundant. In the Middle Darriwilian var. *divergens* is common, but *I. forcipiformis* has appeared in force in C1 and D5, and predominates along with *I. manubriatus, Oncograptus,* and *Cardiograptus* in the higher beds, surviving these last forms which disappear in the Middle Darriwilian, except perhaps locally.

(*e*) *Upper Ordovician.*

Up to the present only two specimens of *Isograptus caduceus* have been recorded from the Upper Ordovician, both of them found by the writer at the same locality—Ba67 (Q.S. 6 S.E.) at the junction of Riddell's and Jackson's Creeks, where there is an extensive exposure of soft, easily split shales, and graptolites may be more readily obtained in good order than at any other outcrop with which I am acquainted on the same horizon—the lowest zone of the Upper Ordovician. The two specimens obtained are of the same type—a narrow tenuous horseshoe-shaped form somewhat resembling var. *lunata* of the lower Castlemainian zones. The nearest relative to this variety is a similar tenuous form found in the C1 beds of Limestone* Creek, Yandoit (Figs. 53, 54), and at the Bullengarook Slate Quarry.

* The record on some copies of Q.S. 15 S.E. showing *Loganograptus* and *Didymograptus bifidus* from this outcrop is inaccurate. A form allied to *Loganograptus logani* is not uncommon, but the commonest form is *Isograptus caduceus,* which from its abundance and characters indicates a high Castlemainian horizon, which the field evidence supports. This horizon is much above the *Didymograptus bifidus* beds. Moreover a fairly thorough search has shown no reason for believing that *D. bifidus* occurs here.

VIII. Other Varietal Forms.

As stated, the simple horseshoe-shaped rhabdosome of *Isograptus caduceus* predominates as high as the Upper Castlemainian. From this horizon there are numerous varieties which show that the acmic stage of the parent species has been reached and that further development was possible only by radical changes leading to new genera or by catagenesis.

The scandent tendency, which led to the rise of the Diplograptidae, affected *I. caduceus* powerfully, and there is a succession of varieties which indicate its effect—varieties *maxima*, *maximo-divergens*, *divergens*, *pertensa*, and *horrida*—as well as others separated as distinct species—*I. forcipiformis*, *hastatus*, *manubriatus*, and *ovatus*—or even distinct genera such as *Oncograptus* and *Cardiograptus*.

At the same time there was a tendency to group thecal origins in the region of the sicula. This is shown in *I. forcipiformis* and in the two genera just mentioned, possibly also in *I. ovatus*. A third tendency, perhaps a modification of that which led to thecal grouping, produced forms with enlarged sicular regions—the manubriate group, including *Isograptus manubriatus*, *I. hastatus*, and *I. dumosus*.

In addition there are the catagenetic varieties. *I. caduceus*, var. *maxima*, passes insensibly through var. *maximo-divergens* into var. *divergens*. Allied to var. *divergens* are several varieties probably catagenetic. The most striking of these is var. *pertensa* (Fig. 31), which so far seems to have been collected only from the Steiglitz district, where it was found in Darriwilian beds by Mr. W. H. Ferguson, the doyen of Victorian graptolite collectors. In this variety the stipes are abnormally long. They diverge at an angle of 340 deg. and then, without altering appreciably in width, run back in straight lines for over 8 cm. The sicular region is spinose, and in distal portions of the stipes there are only 7 thecae in 10 mm. This is one of the most extraordinary varieties of this protean species.

Thomas has collected from Lancefield a form externally resembling var. *pertensa*, but with much shorter stipes, the spinose sicula being its most characteristic feature. This is figured as var. *horrida* (Fig. 32). Whether it should be regarded as distinct from another Darriwilian form which, though without the marked spine, resembles it otherwise, remains open to doubt. This spineless form hovers between var. *divergens*, *I. forcipiformis*, and still another variety which, when small, echoes var. *lunata* of earlier beds, and which I have called var. *imitata* (Figs. 55-59). Var. *imitata* is one of the commonest forms in the Upper Castlemainian, and varies considerably in size. An attenuated horseshoe-shaped form with very thin periderm is found rather rarely from the Upper Castlemainian to the lowest

beds of the Upper Ordovician (Ba67). As stated above, it seems to be a catagenetic form resembling var. *lunata* or a small var. *victoriae,* and is here separated as var. *tenuis* (Figs. 53-54).

This leaves the distinct manubriate forms still to be dealt with as well as *Isograptus forcipiformis,* and the genera of *Oncograptus* and *Cardiograptus.* The choice of varieties is more or less arbitrary, since only those forms have been dealt with which occur fairly commonly. Some of the varieties are locally very abundant, and one cannot foresee that some new locality may not produce forms distinct enough to warrant the addition of even more names to the list. A variety in which the stipes more nearly approached the horizontal I had described as var. *expansa,* but as I had very few specimens I remained in doubt as to whether the appearance might not be the result of accident. Keble and Benson(15) record a var. *spinifer,* but this I have omitted for lack of material. It is likely that, no matter how many varieties are described, there will always be inter-varietal forms.

IX. The Manubriate Species.

It has been usual to refer all forms with large siculae to *Isograptus caduceus,* var. *manubriatus* (T. S. Hall var.), but closer examination shows that they form a group agreeing in this one respect only, and otherwise appear to form a connected series between *Isograptus* and *Maendrograptus.*

The earliest form to appear is here described as *I. hastatus* (Figs. 33-36). It is represented by Hall's figure of the co-type of his var. *manubriatus*(12), but it seems to be quite distinct from the type which is here retained as *I. manubriatus* (Figs. 43-44). Closely allied to *I. hastatus* is *I. dumosus* (Figs. 37-39), which, on the other hand, seems also to approach *I. manubriatus* in its very typical early stages. *I. dumosus* seems also to link up with *I. caduceus* through a variety which is figured as *I. caduceus* var. *velata* (Fig. 40). The characteristics of these forms may be best noted from the descriptions and figures.

(*a*) *Isograptus hastatus* (Figs. 33-36).

T. S. Hall(12) in 1914 described a new variety of *Didymograptus caduceus* (*Isograptus caduceus*) as var. *manubriatus.* He illustrated his description with two figures—a type from a "quarry in hard blue slate, one mile west of school on road from Woodend to Macedon," and a co-type from McPherson's Creek, Steiglitz. The two figures differ, as Hall realized, and an examination of hundreds of specimens has led me to the conclusion that the differences are sufficiently great to warrant the separation of both forms from *I. caduceus* and from each other. From an examination of the collection it also seems that

the Steiglitz form occurs on a lower horizon than the Macedon type, and this accords with my own observations elsewhere. Like so many of our graptolites, each of the forms is rather limited in distribution, occurring at a few outcrops in great numbers, but rare elsewhere. Hall's Steiglitz co-type, characterized by a long narrow wedge-shaped sicular region, is referred to as *I. hastatus*. It is of special interest, as its thecae are not so typically recurved and mucronate as those of *I. caduceus*, and since there are indications that in its early stages it showed a trend towards *Macandrograptus* as represented by *M. tau*, sp. nov., and also towards *I. dumosus*. A fuller description is given in Part 2 of this paper.

(*b*) *Isograptus manubriatus* (Figs. 41-44).

This, with the species immediately above, was described by Hall(12) as a variety of *I. caduceus*, and is represented by his figure (Hall *sup. cit.* pl. xvii., Fig. 12). Since then the term var. *manubriatus* has been used rather freely to cover all large-sicula forms. This was partly due to the fact that the type figure represented a rather rare variety and the type locality could not be identified. It seems almost certain from Dr. Hall's description both of the variety and of its associates that he himself had no opportunity of collecting it in the field.

Isograptus manubriatus differs from *I. caduceus* in the nature of its proximal region and also in the character of the thecae. The first few thecae grow downward along the sicula, thus forming a small "tuft," and later thecae turn backward and upward and enclose the whole sicular region. A peculiar enlargement around the sicula noted in this species and also in *I. dumosus* is notable. Unfortunately little internal structure can be made out in any specimens yet collected, so that the very interesting question of the relation of *I. manubriatus* to *I. caduceus* and also to *Oncograptus* and *Cardiograptus* cannot be answered. From external appearances it would seem that there is a considerable resemblance between *I. manubriatus* and these two genera.

(*c*) *Isograptus dumosus* (Figs. 37-39).

In the Lower and Middle Darriwilian another form is not uncommon in which the sicular region fills most of the space between the stipes. In some of these forms the general outline and the nature of the thecae show such a resemblance to those features of *I. caduceus* that the form is described as *I. caduceus*, var. *velata* (Fig. 40). In others the sicular region is distinctive, the early growth stages resemble those of *I. manubriatus*, and the thecae also differ from those of *I. caduceus*. This form is described as *I. dumosus*, and seems to have affinities with *I. hastatus*.

X. Isograptus forcipiformis and Skiagraptus gnomonicus.

Isograptus forcipiformis was first figured and described by Ruedemann(20) as an extreme development of *Didymograptus caduceus* by the divergence and slenderness of the branches. Forms referable to *I. forcipiformis* are common at certain outcrops, as at the Lower Darriwilian outcrops west of the Bullengarook Slate Quarry and at Ba71, in the same district. They also occur in Upper Castlemainian beds, though much more rarely, and form a majority of all *Isograptus* forms in the Upper Darriwilian beds (Fig. 27). Specimens resembling Ruedemann's variety *nanus* are also found, but I have not considered it necessary to separate them from *I. forcipiformis*. Of special interest in all these forms is the tendency towards concrescence (Fig. 28), a tendency shown also in Ruedemann's figures. The extreme development of the concrescent tendency shown in *I. forcipiformis* would ultimately produce a wholly biserial form indistinguishable from *Diplograptus gnomonicus* in outline, and a specimen is figured (Fig. 29) which may be regarded either as an extreme modification of *Isograptus forcipiformis*, biserial through concrescence, or as *Diplograptus gnomonicus*. From its association with numerous specimens of *I. forcipiformis* and the absence of any undoubted specimens of *D. gnomonicus* it is referred to the former species. In fact, specimens may be obtained which show all stages of approach to the biserial form (Fig. 28). Whether this is the origin of *D. gnomonicus* cannot be definitely stated, but it seems probable that this form is a derivative from *I. forcipiformis*. In the absence of conclusive evidence *Diplograptus gnomonicus* cannot be referred with certainty to *Isograptus*, but there seems little doubt that it is not a true *Diplograptus*. It is therefore made the type of a new genus—*Skiagraptus*—which may be included with the Isograptid family.

XI. Oncograptus and Cardiograptus.

Attention has been directed to the tendency of *Isograptus caduceus* towards concrescence. This tendency may be noticed in forms from the Middle Castlemainian, but is not pronounced till the highest Castlemainian beds are reached. In Zone C2 (Victoria Gully) the horseshoe-shaped rhabdosome is by far the most common. The succeeding variety, var. *maxima*, is of the same general shape, though more robust, but associated with it, and becoming increasingly common in the highest Castlemainian beds, is the variety *maximo-divergens*, in which the stipes turn back more abruptly, gradually widen and then narrow, and in general approach var. *divergens*. These intermediate forms—between var. *maxima* and var. *divergens*—include the largest specimens of *Isograptus* recorded. If the

tendency towards increase in the angle of divergence were carried to extremes the resulting rhabdosome would be biserial at least proximally. This is shown in *I. forcipiformis*. In *Oncograptus* we have a form initially biserial and then developing uniserial stipes. The biserial part is of varying length, sometimes so short that the specimen resembles an initially broad *Isograptus* (Fig. 22). *Oncograptus* seems so closely related to *I. caduceus* that though its early stages are still obscure it seems justifiable to include it in the same family. If it developed from *I. caduceus* it was probably by a distinct break, as no intermediate forms are found in the Upper Castlemainian beds, where they might be expected. At McKenzie's Hill, Castlemaine, a typical C1 locality, one characteristic specimen of *Oncograptus upsilon* was found in association with numerous and particularly large specimens of *I. caduceus*, var. *maximo-divergens*.

Two species of *Oncograptus* have been described, *O. upsilon* T. S. Hall, and *O. biangulatus* Harris and Keble. Typical specimens of these species are easily distinguishable, but there is a gradation from one to the other, and it seems best to regard *O. biangulatus* as merely a variety of *O. upsilon*. The writer's observations on the two forms may be summarized as follows:— There are numerous forms 11 to 14 mm. wide at the bifurcation of the stipes, with stipes inclined at an angle of 320-330 deg. and uniserial stipes about 5 mm. wide. These would be regarded as typically *Oncograptus upsilon** (Fig. 21). (The length of the uniserial stipes does not seem to be important.) Equally as common, but on a somewhat higher horizon, are forms less than 10 mm. wide at the bifurcation, with stipes inclined at a greater angle (330-340 deg.), and with uniserial stipes less than 5 mm. wide. These are typically *Oncograptus biangulatus* (Fig. 23). There are also forms which it is difficult to refer to one species rather than the other, and the direction of pressure has considerable effect on the final dimensions. This is well shown in specimens from a small quarry on the south bank of the Gisborne Creek in allotment 40, Bullengarook, and also in specimens collected by D. E. Thomas in the Lancefield district. Forms showing all gradations between the two described species occur in the same beds at an old slate quarry about a mile south of the site of the old State school on the Calder Highway near Macedon, and E. Ripper(19) records a similar occurrence from the Ingliston district. The thecal characters of both forms are the same as those of *Isograptus caduceus*, and the number of thecae in each case is 9-10 in 10 mm.

The failure of *Oncograptus* to develop its distally uniserial stipes would result in a wholly biserial form. *Cardiograptus* is such a form. Like *Oncograptus, Cardiograptus* shows great

* An inconstant character observed in some late varieties of *Isograptus caduceus* (Fig. 17) is the presence of a web or film connecting the two stipes and surrounding the apical end of the sicula. This is a commoner feature of *Oncograptus* (Fig. 21).

variation in the width of the rhabdosome, but it is interesting to note that most specimens may be classed as either narrow or wide, in this respect bearing some resemblance to the two varieties of *Oncograptus*. It is probably not without reason that *Cardiograptus* appears on the horizon where a derivative of *Oncograptus* might be expected—first in D 4 associated with *Oncograptus*, and then generally surviving that form in higher beds. In this genus the checking of the tendency towards uniserial development may be indicated by the emarginate distal end of *Cardiograptus morsus*. The species failed to resist completely the tendency towards divergence, and yet did not, like *Oncograptus*, give rise to uniserial stipes. In the later species, *C. crawfordi* Harris, the emargination is less pronounced or altogether absent, again as might be expected. The order of appearance of these related forms is—

Isograptus caduceus	var.	victoriae	C2
„	„	maxima	C2—C1
„	„	maximo-divergens ..	C1
„	„	forcipiformis ..	C1—D5
Oncograptus upsilon ..		.. .. ..	D5
„	var.	biangulatus	D5—D4
Cardiograptus morsus ..		.. .. ..	D4
„ crawfordi		.. .. ..	D1

XII. Development of Oncograptus and Cardiograptus.

The deceptiveness of compressed material in the case of *Isograptus caduceus* makes me hesitate to discuss the mode of growth of the proximal parts of *Oncograptus* and *Cardiograptus*. There seems little doubt that the method is the same in each case, juvenile *Cardiograpti* being practically indistinguishable from the same stages of *Oncograptus* (Figs. 24, 25). In both genera the first thecae seem to grow downward almost parallel to and beyond the aperture of the sicula, the later thecae then gradually turning back till the whole sicular region is enclosed between what would be two stipes, but which in these forms makes up the biserial parts of the rhabdosome.

XV. Maeandrograptus spp.

Isograptus hastatus (Figs. 33-36) seems to be related to a form which has greater affinities with *Maeandrograptus—I. dumosus* (Figs. 37-39), and also to a still more maeandrograptid form, *Maeandrograptus aggestus*, sp. nov. (Fig. 51). Another related form which may possibly link up with the Leptograptidae and Dicellograptidae is described as *Maeandrograptus tau*, sp. nov. (Figs. 47-49). As with *Oncograptus* and *Cardiograptus*,

the early stages are obscure, and the available material does not permit a certain reference to any genus. However, the difficulty of placing these forms in their most natural position has to be faced, and they are therefore referred to *Maeándrograptus*. They emphasize the trend towards the grouping of thecal origins in the sicular region—especially *M. aggestus*.

XVI. Other Species.

Didymograptus ovatus T. S. Hall (Figs. 45-46), a distinctive but little-known form, is also referred to *Isograptus*. The details of structure are as obscure as in many other forms described, but the reference to *Isograptus* seems justified, the possible alternative being inclusion under *Oncograptus* as a paracmic form.

A species of reflexed *Didymograptus* from a much lower horizon than any here described has been known for many years, having been collected by Mr. T. Smith, of Eberys, Campbelltown, from the zone of *Tetragraptus fruticosus* and *T. approximatus* (B 5), and provisionally named *Didymograptus eocaduceus* by Mr. R. A. Keble. Investigation of the locality by Mr. D. E. Thomas and the present writer showed that there were in these beds two reflexed forms. In the absence of any evidence that their mode of growth corresponded with that of *Isograptus caduceus*, and taking note of the stratigraphical gap between their horizon and that in which *I. caduceus* seems to make its appearance as a primitive form, it has been decided to describe them as *Didymograpti*, probably unconnected with *I. caduceus*—*Didymograptus eocaduceus*, Keble MS. (Figs. 64-67), and *D. hemicyclus*, sp. nov. (Fig. 68).

XVII. Correlation and Zonal Range of the Isograptidae.

The task of correlating the graptolite succession in Australia with that in other parts of the world is of absorbing interest but of considerable difficulty. The chief criterion—the comparison of parallel associations of forms—is easily agreed upon, but its application is by no means easy. Of the attempts at correlation recently made, only two need be considered in this paper, and then only as far as they concern the zones dealt with—the Castlemainian and the Darriwilian. These are the table (based on the work of Dr. Elles) given in Sir Edgeworth David's Explanatory Notes on a New Geological Map of Australia (Table A) and Harris and Keble's(14) discussion. David quotes Elles's opinion that the sequence of the graptolite zones is practically the same in Australia as in Europe. This opinion does not conflict with the conclusions of Harris and

Keble, but trouble arises when correlation zone by zone is attempted. It is not clear, for example, what relative weight should be attached to the first appearance of new forms, to their appearance first in force, or to their general distribution, nor do published records give more than a mere outline from which to draw conclusions. In Australia also there is the great handicap of undescribed forms, which possibly outnumber those described. It is to be regretted that no attempt has been made in recent years to publish a reasonably complete account of the graptolites occurring at typical localities in each of the principal zones—"typical assemblages." Dr. Hall did this some 40 years ago for the type Lancefieldian locality, but it is needless to state that even this work is in urgent need of revision and supplement. Collections have been made with a view to the task indicated, but considerable labour and time is involved.

With respect to *Isograptus caduceus* the following points must be considered. Firstly, though *Isograptus* makes its appearance in the lowest Castlemainian zone (C 5)—or even lower, according to a personal communication from Mr. R. A. Keble—it is not a characteristic form till the Middle Castlemainian horizon is reached. Secondly, its development in Victoria is on a much more extensive scale than in England, so that while English forms seem comparable with those from our C3 and C2 beds, the higher forms do not seem to be found in Europe.

It is therefore a great advantage to have a recognizable assemblage correlated by a worker familiar with European species. This is provided by Bulman(2) in his reference of South American graptolites to the Llanvirnian (Zones 6 and 7, E. and W.). The Llanvirnian assemblages "are characterized above all by the abundance of *Didymograpti* of the tuning-fork type, and the presence of numerous *Glossograpti* which appear in force for the first time at the base of the zone of *Didymograptus bifidus.*"(4) The exact identity of the chief Australian tuning-fork *Didymograptus* as *D. bifidus* has been queried, but Bulman's work seems to indicate that it is necessary to regard the dependent *Didymograpti* as of limited development and of restricted range in Victoria, and to take the rest of the assemblage as characteristic. Thus, apart from numerous dependent *Didymograpti,* Bulman(2) records *Phyllograptus, Glyptograptus dentatus,* mut. towards *Glyptog. teretiusculus, Amplexograptus* cf. *confertus, Lasiograptus,* and *Glossograptus holmi* from several Bolivian localities. Associated with some or others of these forms are *L. logani* var. *boliviensis, Cryptograptus tricornis* var. *schaferi, I. gibberulus* var. *divergens, Pterograptus* sp., and *Climacograptus* cf. *modestus,* together with other forms of less direct interest at present. Now every one of these forms, even to the varieties, can be correlated with Victorian Darriwil forms. Apart from the more general species, which may not be so

important, it cannot be accidental that such distinct forms as the mutation of *Glyptograptus* towards *G. teretiusculus,* the variety *schaferi* of *C. tricornis,* the loganograptid form or an equivalent (*Brachiograptus etaformis*), a *Pterograptus* closely allied, a *Climacograptus* like *C. modestus,* incoming *Lasiograpti* and *Glossograpti,* should all be characteristic of one zone in Victoria and also in South America. *Isograptus caduceus* var. *divergens,* which is associated with these in South America, occurs rather lower in Victoria (in the lower Darriwilian), but all the other forms are characteristic of the upper Darriwilian (D2 and D1). It seems, therefore, that these beds which represent the upper limit of the range of *Isograptus,* except for its rare survival in the zone of *Diplograptus teretiusculus,* must be correlated as Llanvirnian. The lowest range of the genus is not so definitely fixed, but as there is some evidence that it may not be absolutely absent from the Bendigonian, its lowest limit may be placed provisionally as in beds equivalent to the *Didymograptus extensus* zone (Zone 4 of the Arenigian).

XVIII. Acknowledgments.

Through the kindness of the Secretary for Mines (Mr. W. Baragwanath) I have had every opportunity of examining the extensive graptolite collections of the Geological Survey of Victoria. This privilege has been made more valuable by the unfailing courtesy of the curator of the Geological Museum (Mr. W. S. Abraham), who has never considered any trouble too great when specimens were desired for comparison. The field work owes much to Mr. D. E. Thomas, B.Sc., whose survey work in the Lancefield district dealt with *Isograptus* beds among others, and to Mr. W. Crawford, of Gisborne. Messrs. F. Chapman, A.L.S., and R. A. Keble, F.G.S., have discussed various points with me, and to them I owe my final determination in the matter of synonymy. Through Mr. Keble, as Palaeontologist of the National Museum, I have also had the opportunity of using the Museum specimens of *Didymograptus eocaduceus* and *D. hemicyclus,* presented to the Museum by Mr. T. Smith, of Ebcrys, Newstead (Campbelltown).

Part 2. Description of Species.

ISOGRAPTIDAE, fam. nov.

Biserial, initially biserial, or uniserial forms with stipes diverging at approximately 180° or more, the proximal thecae growing at first entirely downward and either opening in this direction or turning outward, later thecae tending to become scandent. Thecae of the general type of *Didymograptus.*

Remarks.—Until more is known of the early stages of the forms included in this family the characteristics of the family cannot be definitely set out. It includes, however, forms which have developed from *Isograptus caduceus* (or along parallel lines) by a well-marked line of development, resulting from—

(1) postponement of budding;
(2) grouping of thecal origins in the sicular region before stipes arise;
(3) tendency towards concrescence and therefore towards scandent growth.

It therefore seems to be a natural family, and, as such, worthy of distinct rank.

Isograptus Moberg, 1892.

Genotype *Didymograptus gibberulus* Nicholson, 1875.

Original diagnosis (Translation).

Two branched rhabdosome, both branches of which grow out bilaterally symmetrical from the sicula. Each branch considered by itself is not bilaterally symmetrically formed. The two impressions which one of these graptolites leaves on a shale surface and its counterpart always show in the matter of the proximal end (including the sicula) a somewhat different appearance. One can therefore distinguish a front and a back, and consequently also a right and a left branch.

Amendment to this generic diagnosis(3).

One of the most important characteristics of the genus is the fact that the first stipe develops not from th 1^1 as in the Dichograptidae in general, but from th 1^2 via a second crossing canal. The first few thecae of both stipes grow entirely downwards and the stipes, which are of considerable width at their origin, taper gradually to their distal extremities. As there is so little known of species other than *I. gibberulus*, it is a matter of doubt which characters are of generic importance.

Note by the present writer.—The genus is here enlarged to include forms which are almost certainly closely related to *I. gibberulus*, since the reference of them to the same genus seems more scientific than the perpetuation of separate genera. The crucial test is probably the origin of the first stipe from th 1^2 instead of from th 1^1, though owing to the compression of material examined, it is difficult to be certain of this point. Bulman's "gradual tapering" of the stipes is almost certainly not of generic importance.

Isograptus manubriatus (T. S. Hall).

(Plate VI., Figs. 1A—1L.)

Didymograptus caduceus var. *manubriatus*, T. S. Hall var. (partim). *Proc. Roy. Soc. Vic.* (n.s.), xxvii., (1) pp. 108-109, pl. xvii., fig. 12 (non fig. 13), 1914.

Hall's original description reads:—"Differs from the typical form by the immense size of the sicula which at the point of separation of the branches is as wide as the branch itself. Thecae 10 in 1 cm. Branches diverging at 130° to 140° and varying from 2 to 3 mm. in width. There is considerable range in the width of the branches and the angle of divergence, but the great size of the sicula is remarkable."

Hall's figures show that he included the forms which I have separated, *Isograptus hastatus* and *I. manubriatus*, as different aspects of the same variety of *Didymograptus* (*Isograptus*) *caduceus*. He cites two localities—a type (Fig. 12 *supra*) from "quarry in hard blue slate 1 mile west of school on road from Woodend to Macedon" and a co-type (Fig. 13 *supra*) from "Macpherson's Creek, Steiglitz." This latter form I regard as distinct, viz., *I. hastatus*. The first form I now refer to *I. manubriatus*, considering its early stages to be so different from those of *I. caduceus* as to accord it specific rank. There is some doubt about the type locality. The "school" is presumably the school, since removed, on the west side of the main road, 3 miles south of Woodend Post Office, and practically on the Main Divide. I searched the country on the northern slopes of the Divide west of this school, but failed to find either a quarry or any place that looked a possible site for a quarry, but on repeating the search in company with D. E. Thomas, we broke from a loose block of rock a specimen which might well pass for Hall's type. It is possible, therefore, that we may have overlooked the quarry—an easy thing to do in such densely timbered country, but the less probable since local residents seemed unaware of any quarry in that neighbourhood. They did, however, indicate a quarry about a mile south-south-east of the school, which answers in all other respects to Hall's description. In the waste slabs from this quarry *Isograptus manubriatus* occurs in thousands, making up, I should judge, over 90 per cent. of all graptolites present. Except at this locality and at some others in the same district from which graptolites are not easily obtained, the typical form is comparatively rare, but from the material available a good knowledge of the species may be obtained—that is, as far as the external form is concerned, for as so often is the case, internal detail is hard to make out.

The sicula appears to be long and narrow (Fig. 1A), but round it what appears as a conical film develops. The first thecae (how they originate I cannot make out) grow downwards

parallel to the sicula and form a "tuft," so that juvenile specimens have a very characteristic appearance (Fig. 1E). This juvenile rhabdosome closely resembles the corresponding stage of *Isograptus dumosus* sp. nov., and I collected it from more than one Castlemaine locality without being able to refer it to any known species. Later thecae turn back and upwards, enclosing the whole sicular region and giving the species its characteristic appearance.

The angle the stipes finally make varies, but is about 300° as a rule (300° in Hall's type). I cannot understand Hall's statement that the branches diverge at 130 to 140°, as this does not agree with either of his figures. The thecae number about 10 in 10 mm., resemble those of *Isograptus caduceus* in general form, but have rather less complete overlap and a denticle which, though pronounced, is directed outwards rather than downwards, so that the thecal apertures open upwards rather than outwards. The apertural margin is also less concave.

In view of its evident relation to *Isograptus caduceus* the species is included under *Isograptus*. Among the numbers of specimens collected are some which approach *Isograptus* much more closely than others. It seems most closely related to *I. dumosus* and *I. hastatus*. This latter form is, however, commonest on a lower horizon (C1—Upper Castlemainian).

Horizon and Localities.—The confusion between *Isograptus caduceus* var. *velata, I. dumosus. I. hastatus, I. manubriatus,* and possibly other forms with a prominent sicula (all being grouped as *Didymograptus caduceus* var. *manubriatus*) renders past records of the species unreliable. It occurs rather rarely on Chinaman's Creek east of Muckleford Railway Station (Castlemaine), on the Maldon Pipe Line west of Barker's Creek in the same district, and is common on the same horizon (Lower to Middle Darriwilian) at several localities in the Macedon and Gisborne district, as, for example, in the railway cuttings near Macedon Railway Station, west of the Glendoon Spur (Gisborne), and especially at the type locality discussed in detail above—"Willey's Quarry," less than 1 mile west of main Gisborne to Macedon road (Calder Highway), on southern slope of Divide, about 38½ miles from Melbourne, according to the road mile-posts. At this locality it is associated with an exceptionally complete Lower Darriwilian (D4) assemblage of graptolites:—

Dichograptus octobrachiatus (J. Hall)—large, typical forms.
Tetragraptus quadribrachiatus (J. Hall).
„ serra (Brong.).
„ ? headi (J. Hall).
„ spp.
Phyllograptus sp. (probably P. nobilis H. and K.).
Goniograptus speciosus, T. S. Hall (probably the type locality for this species).
Goniograptus sp.
Trigonograptus ensiformis (J. Hall).

Didymograptus v-deflexus, H. and K.
„ spp. (horizontal series).
Isograptus caduceus var. divergens, Harris.
„ dumosus, sp. nov.
„ manubriatus (T. S. Hall), extremely common.
Skiagraptus gnomonicus (H. and K.).
Oncograptus upsilon, T. S. Hall.
„ „ var. biangulatus, H. and K.
Cardiograptus morsus, H. and K.
Maeandrograptus tau, sp. nov.
cf. Thamnograptus capillaris (Emmons).

as well as multi-branched forms which could not be definitely identified.

Isograptus hastatus, sp. nov.

(Text-figs. 33-36.)

Didymograptus caduceus var. *manubriatus*, T. S. Hall var. (partim). *Proc. Roy. Soc. Vic.* (n.s.), xxvii., 1914, plate xvii., fig. 13 (non fig. 12).

Description.—Rhabdosome small, consisting of two stipes about 1 cm. long diverging from a long dagger-like sicula and turning back till they make an angle of 328°-330°, tapering gradually but slightly, and not approaching each other distally. Thecae 10-12 in 10 mm., conical tubes, overlapping a little more than half and with a denticle less pronounced than that of *Isograptus caduceus*. Apertures slightly concave, making an angle of up to 140° with the axis of the stipe.

Remarks.—The fact that Hall figured this form under *Didymograptus caduceus* var. *manubriatus*, gives a good idea of its general appearance, but it cannot be mistaken for a typical *I. manubriatus*, as indeed Hall recognized when he figured it as well as the other form. The term " sicula " is used to include the whole sicular region, as my material does not permit the detail of the proximal part to be made out. It seems, however, that the sicula is itself large, but is increased in size by the growth parallel and adherent to it of the first thecae, thus anticipating the maeandrograptid type of development and leading towards *Maeandrograptus tau* Harris. The grouping of thecae around the sicular aperture also connects the species with *Isograptus dumosus*, and forms are figured which cannot be referred to either of these species with certainty.

Horizon and Localities.—Although it is not unlikely that some of my records of *Isograptus manubriatus* may refer to the present species, since Hall, as stated, included the two forms in the same variety, my collection includes *I. hastatus* chiefly from Upper Castlemainian beds. It is usually rather rare, but occasionally —as is the case with so many of our species—it is locally very common, as for example on the Sandy Creek road near Bagshot (Bendigo) and at Macpherson's Creek (Steiglitz). It therefore seems to be typical of a lower horizon than *I. manubriatus*.

ISOGRAPTUS DUMOSUS, sp. nov.

(Plate VI., Figs. 2A—C.)

Description.—Rhabdosome small, less than 5 mm. in length and breadth, in shape the segment of a circle with the apex of the sicula as the centre. The sicula appears to be broadly triangular. From it a "tuft" of thecae grow as in *I. manubriatus*. Turning outwards and upwards from this, later thecae form ascending stipes which enclose the whole sicular region and may continue somewhat beyond it, though rarely far. The thecae are curved tubes, overlapping almost completely at first, but with decreasing overlap distally. Apertures straight or slightly concave.

Remarks.—The distinctive shape of the rhabdosome of this species—a broad sicular angle subtended by the arc of a circle—enables it to be easily recognized, particularly as the periderm seems to have been of considerable thickness. Forms are found which by a narrowing of the sicular region and a lengthening of the stipes approach *Isograptus hastatus*. On the other hand forms with typical *I. caduceus* thecae link that species with *I. dumosus* through *I. caduceus* var. *velata*. *I. dumosus* is seemingly not derived from *I. caduceus* through var. *velata*, as it is well established before that variety appears in D4. A more probable derivation is through *I. hastatus*.

Horizon and Localities.—Rather rare in the Upper Castlemainian of Rae Street, and McKenzie's Hill (Castlemaine), and Limestone Creek (Yandoit). Common in the Lower Darriwilian of Gisborne (Ba71) and the middle Darriwilian (D4-3) of Chinaman's Creek, Muckleford. Probably recorded under *Didymograptus caduceus* var. *manubriatus* from other localities.

ISOGRAPTUS OVATUS (T. S. Hall, sp.).

(Text-figs. 45, 46.)

Didymograptus ovatus T. S. Hall, *Rec. Geol. Surv. Vict* i. (1), p. 33, Fig. 1, 1902.

Description.—As Hall's original account is included in a general mining report, possibly not readily accessible, it is given here practically in full.

> "Hydrosome stout, branches abruptly recurved and gradually approaching one another so that the polypary resembles in outline an imperfect specimen of *Phyllograptus typus*. Branches of a uniform width of 1 mm., or to the tip of the mucronate extensions of the thecae, about 2 mm. Sicula long and slender with a delicate virgula. Thecae curved, expanding, about .5 mm. wide, overlapping by one-half their length, and at a distance of about 10 mm. from the sicula inclined at an angle of 40°, outer margins curved, apertural margins deeply concave and produced so as to make with the outer margin a stout spinose mucronate extension of about 1 mm. in length. Thecae numbering 12 in 10 mm."

Hall further remarks—"The species is closely related to *Didymograptus caduceus* Salter, but differs in the form of the aperture of the thecae as well as in the more abrupt reflexion of the branches, which maintain a constant rate of curvature instead of becoming almost straight distally, as is the case in Salter's species."

Remarks.—This description was drawn up from a single specimen from Sandy's Creek, Tabberabbera (Gippsland). In the 30 years which have since elapsed three other specimens have been found—two from Turner's Quarry, allotment 27B, Bittern, and one at 8-Mile Camp on the Howqua River, above Fry's. The type specimen is the largest, but the general characters of all agree except that in the smaller specimens the thecae are rather more closely spaced. In none of the specimens is internal detail shown, but it is clear that *I. ovatus* is deeper over the sicular region than *I. caduceus*, in this respect showing greater resemblance to *I. forcipiformis, I. manubriatus*, and *Oncograptus*. It therefore illustrates the tendency towards concrescence noted in these forms—the grouping of thecal apertures near the sicula and delayed reflexion of the stipes. The character of the thecal apertures, as Hall's description shows, marks also a departure from the typical *Isograptus caduceus*, and brings the species nearer to *I. manubriatus* and *I. hastatus*, from which forms it is easily distinguished by the absence of the enlarged sicula.

Horizon and Localities.—Hall's type is from Upper Ordovician beds. Turner's Quarry and the Howqua River localities are the highest beds of the Darriwilian.

Genus **Maeandrograptus** Moberg.

Genotype *Macandrograptus schmalenseei* Moberg. *Geol. Foren. Forh.* xiv., p. 344, pl. viii., figs. 9-10, 1892.

Several thecae proceed directly from the sicula in the neighbourhood of the broad end. The form of the initial part recalls somewhat that of the genus *Dicellograptus*. The distal parts of both branches are on the contrary constructed on the *Didymograptus* plan, for which reason the new genus may to some extent be regarded as a connecting link between *Dicellograptus* and *Didymograptus*. (Translation of Moberg's original diagnosis as given by Bulman, (3), p. 25.)

Bulman continues, "The structure of the proximal end in this genus is not quite so clear as in *Isograptus* (i.e. *Didymograptus caduceus*), but seems to be of essentially the same type. Moberg was apparently misled by the rapid development of the first three thecae of each stipe into the belief that three primary thecae leave the sicula on each side. . . . From an examination of the paratypes it appears that as in *Isograptus*, th 2^1 is derived from th 1^2 (not th 1^1) but it arises sooner in *Macandrograptus* than it does in *Isograptus*. . . . After adhering to the sicula for some distance th 1^1 turns and grows away in a

reclined direction, and th 1^2 grows in a corresponding direction after crossing the sicula. . . . the thecae are long sinuous tubes, with a considerable amount of overlap that yet increases distally."

Maeandrograptus tau, sp. nov.

(Plate VI., Figs. 5A—D.)

Description.—Rhabdosome usually small (less than 1 cm. long), consisting of short stipes growing almost at right angles from an abnormally long sicula (up to 5-6 mm. in length). Thecae inclined at a low angle, overlapping one-half to one-third, ventral margins with sigmoidal curvature, apertures concave and approximately normal to the axis of the stipe.

Remarks.—The length of the sicula compared with the usually short stipes gives the rhabdosome the appearance of a T, and distinguishes it from any other species. At one locality larger forms are found (see Fig. 5A) which have some resemblance to *Leptograptus* or *Dicellograptus*. How the first theca arises and how the stipes originate I am unable to determine with certainty, but it is probable that the apparent sicula is really a compound structure consisting of the sicula and the first thecae, the latter growing at first parallel to it and then turning aside. It is for this reason that the form is included provisionally under *Maeandrograptus*.

The thecae are not of the typical *I. caduceus* type, but relationship to that species may be traced through *I. hastatus*. It would be difficult to distinguish between *I. hastatus* and a specimen of *M. tau* with reflexed stipes. At Willey's Quarry, Macedon, forms with stipes nearly 10 mm. long are found, and the stipes (whether as the result of accident cannot be determined) occasionally show a divergence of rather less than 180°. The usual angle of divergence is 180° or a little more, and most specimens have only three or four thecae in each stipe.

As stated, the reference to *Maeandrograptus* is tentative, but the form seems to be neither a typical *Didymograptus* nor a *Leptograptus*.

Horizon and Localities.—Not uncommon in the blue and bleached shales of Ba71, Gisborne (Q.S. 6 S.W.) with a typical lower Darriwilian assemblage, and at some neighbouring outcrops. Rather rare, and often of large size, at Willey's Quarry, Macedon, on the next higher horizon (D 4).

Maeandrograptus aggestus, sp. nov.

(Plate VI., Figs. 6, 7A, 7B.)

Description.—Rhabdosome small, almost of the shape of an equilateral triangle with 4 mm. sides, with the sicula pointing to the apex and the two adjacent sides rather concave. This

shape results from the growth from a large but indistinctly shown sicula of thecae at first directed downwards, and the later development of thecae, which grow downwards at first and then turn outwards so that they are almost parallel to each other, overlapping, and at right angles to the sicula. Thecae, long tubes circular or possibly sub-rectangular in section, the first thecae overlapping by about one-half, the later thecae apparently in contact for all their length. Apertures slightly concave and almost parallel to the axis of the sicula.

Remarks.—This description was drawn up from the type specimen, both obverse and reverse of which were found. The later discovery of what seems to be probably a juvenile stage of the species does not make any alteration necessary, but seems to make clearer the relationship to the manubriate *Isograpti*. Apart from this resemblance the mode of growth is quite unlike that of any graptolite yet described from Victoria, and the mature rhabdosome is quite distinctive. Although it is evidently quite distinct from *Maeandrograptus schmalenseei* Moberg, inclusion in the same genus seems preferable to the creation of a new genus.

Horizon and Localities.—The two specimens referred to above are the only ones yet recorded. They come from the Upper Castlemainian bleached shales of Limestone Creek, allotment 2, section 2, Yandoit (Q.S. 15, S.E., Loc. Fa 3).

Skiagraptus, gen. nov.

Biserial graptolites in which the proximal thecae grow alongside the sicula with their apertures directed in the same general direction, later thecae gradually becoming more and more horizontal but with their ventral walls remaining concave towards the proximal part of the rhabdosome.

Skiagraptus gnomonicus (Harris and Keble).

(Plate VI., Figs. 3, 30.)

Diplograptus gnomonicus H. and Keble. *Proc. Roy. Soc. Vic.* (n.s.), xxix. (1), plate 1, figs. 5, 6 (figures only), 1916.

Diplograptus gnomonicus Harris. *Ibid.* (n.s.), xxxvi. (2), p. 86 (description only), 1924.

There is little to add to the original description. The probable relationship with *Isograptus forcipiformis* has been indicated in part I. of this paper. The figures give a good idea of this small, tenuous, but distinctive graptolite, which since 1926 has been found to occur in Darriwilian beds in the Gisborne and Lancefield districts, and in the Brisbane Ranges, as well as at Castlemaine, whence it was originally described. Some of the best specimens have been obtained at Willey's Quarry, Macedon (D4).

Family DICHOGRAPTIDAE.

Genus **Didymograptus.**

DIDYMOGRAPTUS EOCADUCEUS, sp. nov.

(Plate VI., Figs. 8A, 8B.)

Description.—Two stipes, bending in opposite directions, upwards and backwards, form a rhabdosome of horse-shoe shape, the angle of divergence, at first little more than 180°, rapidly increasing until the stipes are parallel to each other or even converge distally. Sicula about 1.5 mm. long and 0.5 mm. wide. The stipes are short (greatest length observed about 10 mm.), narrowest over the second or third theca in each stipe—probably due to reflexion—and then practically constant in width (1 mm., or with denticles, 1.5 mm.). Thecae 11-12 in 10 mm., about 2 mm. long and about half as wide, curved tubes overlapping about one-half, with a pronounced denticle directed outwards or slightly downwards. Apertures usually slightly concave, directed upwards to make an angle of from 100 to 130° with axis of stipe.

Remarks.—This distinctive form closely resembles *Isograptus caduceus* in general form, but is apparently a typical *Didymograptus*. It can be distinguished by the simplicity of its proximal region, which shows none of the complexity of *Isograptus* of similar aspect. The thecae, too, though not unlike those of *I. caduceus,* have less overlap, and the apertures are directed at a different angle. The whole form is less rigid than *I. caduceus*, and gives one the idea—confirmed by its stratigraphical position—of being more primitive.

Horizon and Localities.—Known with certainty only from Lower Bendigonian beds of Campbelltown (allotments 16, 17, and 22) where it was originally collected by Mr. T. Smith, and provisionally named by Mr. R. A. Keble. Collected later from the same localities, where it is not uncommon, by Mr. Thomas and myself under Mr. Smith's guidance. It is, as stated above, considerably below the *Isograptus* beds, and no relationship between the two forms can be traced. A doubtful example was collected from beds of similar age at Axedale by Mr. J. J. Caldwell and myself.

DIDYMOGRAPTUS HEMICYCLUS, sp. nov.

(Plate VI., Fig. 4.)

Description.—Two uniformly narrow stipes—less than 1 mm. over all—diverge from a short sicula to form almost a perfect semicircle. The sicula is about 1 mm. long and half as wide. The stipes arise sub-orally in typical didymograptid fashion. The thecae are long conical tubes, 11 in 10 mm., inclined at a low angle and with an overlap of about one-third. The ventral and apertural margins are slightly concave and the angle between

aperture and axis of stipe is over 90°, i.e., the denticle continuing the apertural margin is directed outwards and somewhat towards the sicular end of the rhabdosome.

Remarks.—This form cannot be mistaken for any other, except possibly, when more than usually robust, for a *D. eocaduceus* narrower than usual. It is a characteristic *Didymograptus,* but strange to say, its nearest relations as regards thecal characters would seem to be horizontal didymograpti of the *D. cuspidatus* type occurring on a much higher horizon (Upper Castlemainian and Darriwilian). It also has some external resemblance to *Isograptus caduceus* var. *tenuis.*

Horizon and Localities.—Not uncommon in allotments 16 and 17, Campbelltown, in the lower Bendigonian beds, associated with *D. eocaduceus* and forms typical of the horizon. Collected by Mr. Smith, and then by Mr. Thomas and myself, as described under *Didymograptus eocaduceus.*

Explanation of Text Figures.

All specimens figured are from the writer's collection except where otherwise stated.

Fig. 1.—Isograptus caduceus, var. primula, nov., C5. South of Blacksmith's Gully on Chewton-Fryerstown road.

Fig. 2.—Isograptus caduceus, var. primula, nov., C5. On race west of Monk Hill, Castlemaine.

Fig. 3.—Isograptus caduceus, var. lunata, nov., C5. Same locality as Fig. 1.

Fig. 4.—Isograptus caduceus, var. lunata, nov., C4. Quartz Hill, Castlemaine (Coll. Geol. Surv. Vict.).

Fig. 5.—Isograptus caduceus, var. lunata, nov., C3. Steiglitz (No. 6293, Coll. Geol. Surv. Vict.).

Fig. 6.—Isograptus caduceus, var. lunata, nov., C3. East of Victoria Gully, Castlemaine.

Figs. 7, 8, 9.—Isograptus caduceus, var. victoriae, nov., C2. Victoria Gully, Castlemaine. Figs. 8 and 9 are very typical. The locality is Hall's type Victoria Gully outcrop—"spoil heap from a small mining shaft on the east side of the gully." Ref. (9), p. 71.

Fig. 10.—Isograptus caduceus, var. victoriae, nov., C2. South of Specimen Gully, Barker's Creek, Castlemaine.

Fig. 11.—Isograptus caduceus, var. maxima, nov., C2-C1. Back road from Castlemaine to Barker's Creek. Smaller than typical var. maxima, but distinct from var. victoriae.

Fig. 12.—Isograptus caduceus, var. maxima, nov. C1. Bullengarook Slate Quarry, Allot. 43A, Bullengarook. Typical of variety.

Fig. 13.—Isograptus caduceus, var. maximo-divergens, nov., C1. Between Castlemaine Military Rifle Range and town. Typical, but by no means largest form.

Fig. 14.—Isograptus caduceus, var. divergens, Harris, D3. Chinaman's Creek, Muckleford.

Fig. 15.—Isograptus caduceus var. divergens, Harris, D3. Same locality. Shows straighter stipes—a paracmic form of the variety.

Fig. 16.—Isograptus caduceus, var. divergens, Harris, D3. 94 miles 16 chs. on Axedale-Bendigo railway. A still more degenerate specimen of the variety.

Fig. 17.—Isograptus caduceus, var. divergens, Harris, D3. Lancefield. Shows axilar film. (Coll. D. E. Thomas.)

Fig. 18.—Isograptus caduceus, var. divergens, Harris, D3. One chain west of loc. of Fig. 16. Shows exceptional thickening of proximal region.

Figs. 19, 20.—Oncograptus upsilon, var. biangulatus, D4. Lancefield. Two specimens from the same slab showing variation in length of biserial part. (Coll. D. E. Thomas.)

Fig. 21.—Oncograptus upsilon, T. S. Hall, D5. Small quarry on Gisborne Creek, west of loc. of Fig. 12. Typical of species, which at this locality has stipes 6 cms. long.

Fig. 22.—Oncograptus upsilon, var. biangulatus, nov., D4. Same locality as Fig. 14. Showing very short biserial part and axilar film. The reverse of this showed that the shortness was not due to loss in splitting.

Fig. 23.—Oncograptus upsilon, var. biangulatus, nov., D4. Same locality. Typical of the variety.

Fig. 24.—Oncograptus upsilon, var. biangulatus, nov., D4. Juvenile form. Same locality.

Fig. 25.—Cardiograptus morsus, H. and K., D3. Gisborne Creek, near Gisborne gold mine. Mature form of narrow variety. Compare with Fig. 24. As Oncograptus does not occur here, nor the narrow C. morsus at Chinaman's Creek, there is no doubt as regards identification.

Fig. 26.—Cardiograptus morsus, D4. Same locality as Figs. 22-24. Typical wider form.

Fig. 27.—Isograptus forcipiformis (Ruedemann), D1. Allot. 19, Sect. III., Strathfieldsaye. Typical of D1 form of the species.

Fig. 28.—Isograptus forcipiformis, D5. Ba71, Gisborne Creek. Four examples from the same slab, showing concrescence.

Fig. 29.—Isograptus forcipiformis, D5. Same locality. Completely concrescent form (Skiagraptus gnomonicus, H. and K.)

Fig. 30.—Skiagraptus gnomonicus (Harris and Keble), D4. Willey's Quarry, Macedon. Typical. (Coll. Harris and Thomas.)

Fig. 31.—Isograptus caduceus, var. pertensa, nov., D—, Steiglitz (Loc. 57Sz., junction of Brown's Gully and Sutherland's Creek). (Coll. W. H. Ferguson, Geol. Surv. No. 6719.)

Fig. 32. Isograptus caduceus, var. horrida, nov., D—, Lancefield. (Coll. D. E. Thomas, Geol. Surv. No. 31308. No. 31309 shows an example with stipes three times as long.)

Fig. 33. Isograptus hastatus, n.s., sp. nov., D5. Same locality as 28 and 29. Juvenile form.

Fig. 34.—Isograptus hastatus, n.s., sp. nov., C1. Allot, 2, Sect. 2, Yandoit. Juvenile form showing resemblance to I. dumosus (Fig. 39).

Fig. 35.—Isograptus hastatus, n.s., sp. nov., C1. Rae-street, Castlemaine.

Fig. 36.—Isograptus hastatus, n.s., sp. nov., C1. Sandy Creek-road, near Bagshot, Bendigo. Type.

Fig. 37.—Isograptus dumosus, sp. nov., D5. Same locality as Fig. 28. Juvenile form. Cf., Fig. 41.

Fig. 38.—Isograptus dumosus, sp. nov., D4. Same locality as Fig. 14. Juvenile form.

Fig. 39.—Isograptus dumosus, sp. nov., D5. Same locality as 37. Typical mature form.

Fig. 40.—Isograptus caduceus, var. velata, nov., D4. Same locality as Fig. 38. Shows resemblance to I. dumosus and also to I. manubriatus. Compare also with specimens in Geol. Surv. Coll. of Thomas, No. 31331. Lancefield, Loc. LL—34.

Figs. 41, 42, 43, 44.—Isograptus manubriatus (T. S. Hall), D4. Willey's Quarry, Macedon. Growth stages showing typical "tuft" of proximal thecae, and variations of adult forms. The range of variation is too great to be illustrated. (Coll. Harris and Thomas.)

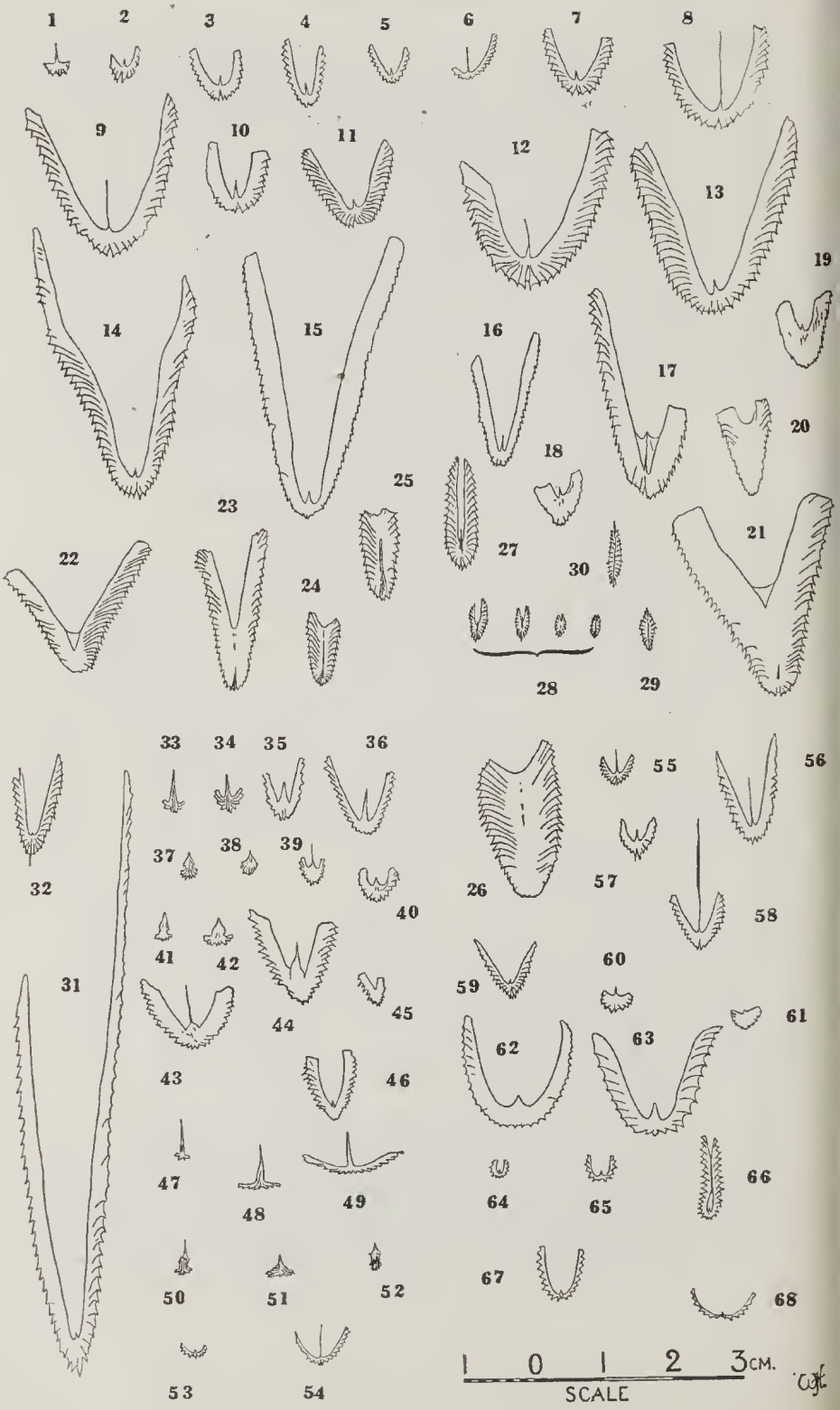

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Fig. 45.—Isograptus ovatus (T. S. Hall), D1. Turner's Quarry, Parish of Bittern. Shows concrescent proximal part.

Fig. 46.—Isograptus ovatus (T. S. Hall), D1. 8 mile Stockyard, Howqua River. (Coll. Harris and Thomas.)

Fig. 47.—Maeandrograptus tau, sp. nov., D5. Same locality as Fig. 28. Juvenile form.

Fig. 48.—Maeandrograptus tau, sp, nov., D5. Same locality as Fig. 47. Typical form.

Fig. 49.—Maeandrograptus tau, sp. nov., D4. Same locality as Fig. 42. Larger forms are found at this outcrop than elsewhere.

Fig. 50.—?Maeandrograptus aggestus, sp. nov., C1. Same locality as Fig. 34. Doubtfully referred to this species, but possibly an immature I. dumosus. (Cf., Fig. 52.)

Fig. 51.—Maeandrograptus aggestus, sp. nov., C1. Same locality as Fig. 52. Type.

Fig. 52.—?Isograptus dumosus, D5. Same locality as Fig. 28. For comparison with Fig. 50.

Figs. 53, 54—Isograptus caduceus, var. tenuis, C1. Same locality as Fig. 34.

Figs. 55, 58.—Isograptus caduceus, var. imitata, nov., C1. Same locality as Fig. 34.

Figs. 56, 57.—Isograptus caduceus, var. imitata, nov., C1. McKenzie's Hill, Castlemaine.

Fig. 59.—Isograptus caduceus, var. imitata, nov., D5. Same locality as Fig. 28. Figs. 55-59, though showing differences from each other all represent paracmic forms echoing earlier varieties, particularly var. lunata, and are therefore grouped as var. imitata.

Fig. 60.—Isograptus caduceus, var. victoriae, nov., C2. Same locality as Figs. 7-9. Juvenile form. Showing resemblance to var. primula.

Fig. 61.—Isograptus caduceus, var.?, D1. Bb29, Cobaw. Showing resemblance to var. primula, though more compact.

Figs. 62, 63.—"Didymograpsus caduceus," Salter. Line copies of Salter's figures to illustrate original description by species (22).

Figs. 64-67.—Didymograptus eocaduceus, sp. nov., B5. Campbelltown. Showing variation in form of rhabdosome. Fig. 66 is an exceptionally well preserved form compressed. (Coll. T. Smith.)

Fig. 68.—Didymograptus hemicyclus, sp. nov., B5. Campbelltown. (Coll. T. Smith, and presented to Nat. Museum.)

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Explanation of Plate VI.

All specimens are enlarged three times.

1A–1I. *Isograptus manubriatus* (T. S. Hall, sp.).
1B and 1C, 1E and 1F show forms in about the same stage of development, but with long and short sicular regions. Both these varieties seem equally common. All from Willey's Quarry, Slaty Creek, Macedon, except 1I, which is from an isolated slab about 1 mile west of old school site on the Main Divide, 3 miles south of Woodend 1A-1H in Geol. Surv. Museum, 1I No. 13803, Nat. Museum. (Coll. Harris and Thomas.)

2A–2C. *Isograptus dumasus*, sp. nov.
2A, Immature form (cf. 1E). 2B-2C, Mature forms. Left bank of Gisborne Creek (Ba71, Q.S., 6 S.W. Geol. Surv. Vict.), Gisborne. In Geol. Surv. Museum. (Coll. W. J. H.)

3. *Skiagraptus gnomonicus* (H. and K.). Willey's Quarry, Macedon. In Geol. Surv., Museum. (Coll. Harris and Thomas.)

4. *Didymograptus hemicyclus*, sp. nov. Campbelltown, No. 13797, Nat. Mus. (Coll. by T. Smith.)

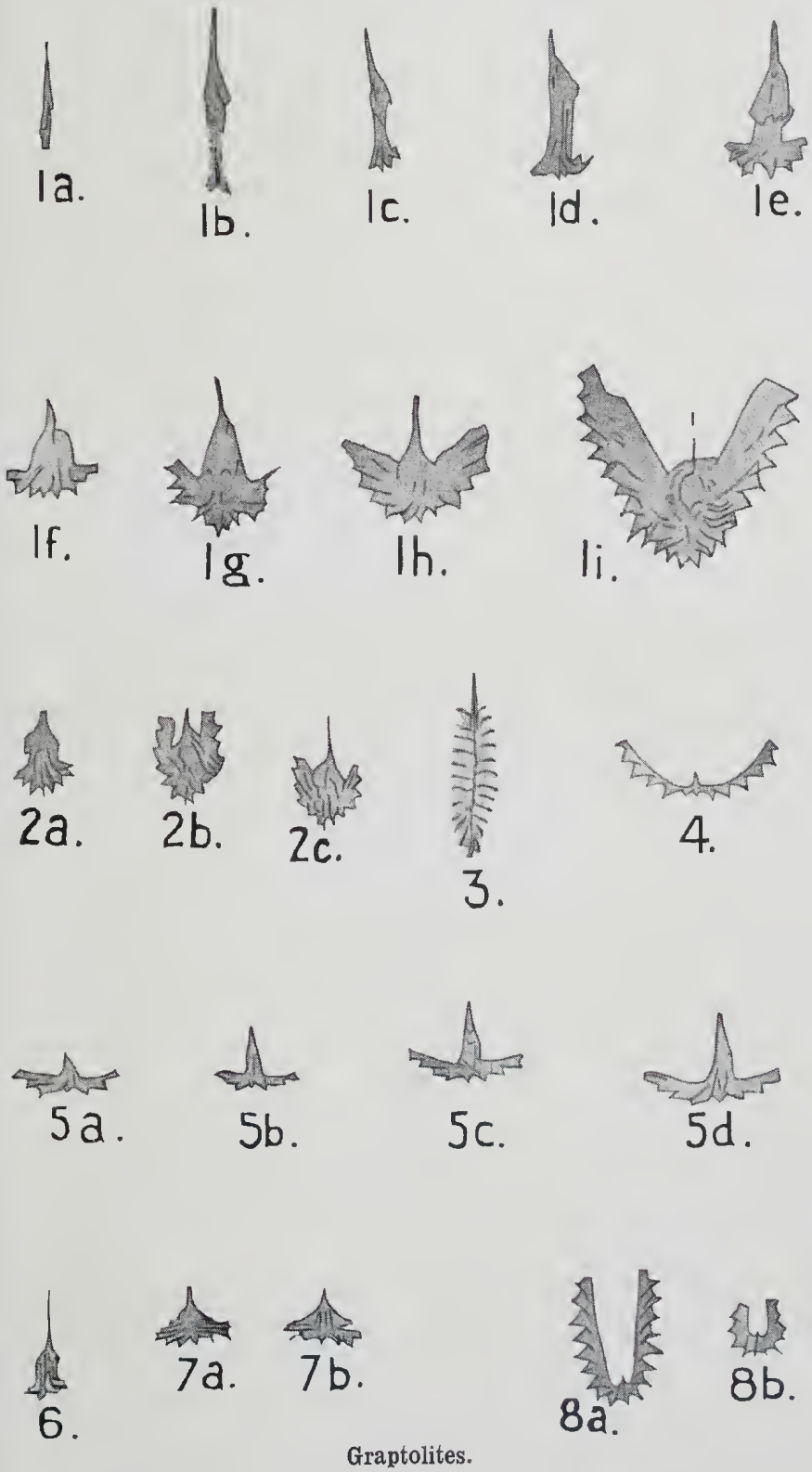
5A–5D. *Macandrograptus tau*, sp. nov., Ba71.
5A, Reverse side of type.
5D, Holotype. No. 13798, Nat. Mus.
5B, 5C, Forms with slightly different appearance. Geol. Surv. Museum. (Coll. W. J. H.)

6. *Macandrograptus aggestus*, sp. nov., or *I. dumosus*, sp. nov.
Juvenile form showing turn of thecae and also thecal buds. Allot. 2 of Sect. 2, Yandoit. (Fa3, Q.S. 15, S.E. Geol. Surv. Vict.) Geol. Surv. Museum. (Coll. W. J. H.)

7A–7B. *Macandrograptus aggestus*, sp. nov. Obverse and reverse of type. Allot. 2 of Sect. 2, Yandoit. No. 13799, Nat. Mus. (Coll. W. J. H.)

8A. *Didymograptus cocaduccus*, sp. nov. Allot. 16, Campbelltown. No. 13800, Nat. Mus. (Coll. by T. Smith.)

8B. *Didymograptus cocaduccus*, sp. nov. A smaller form, from same locality. Geol. Surv. Museum. (Coll. Harris and Thomas.)



Graptolites.

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